

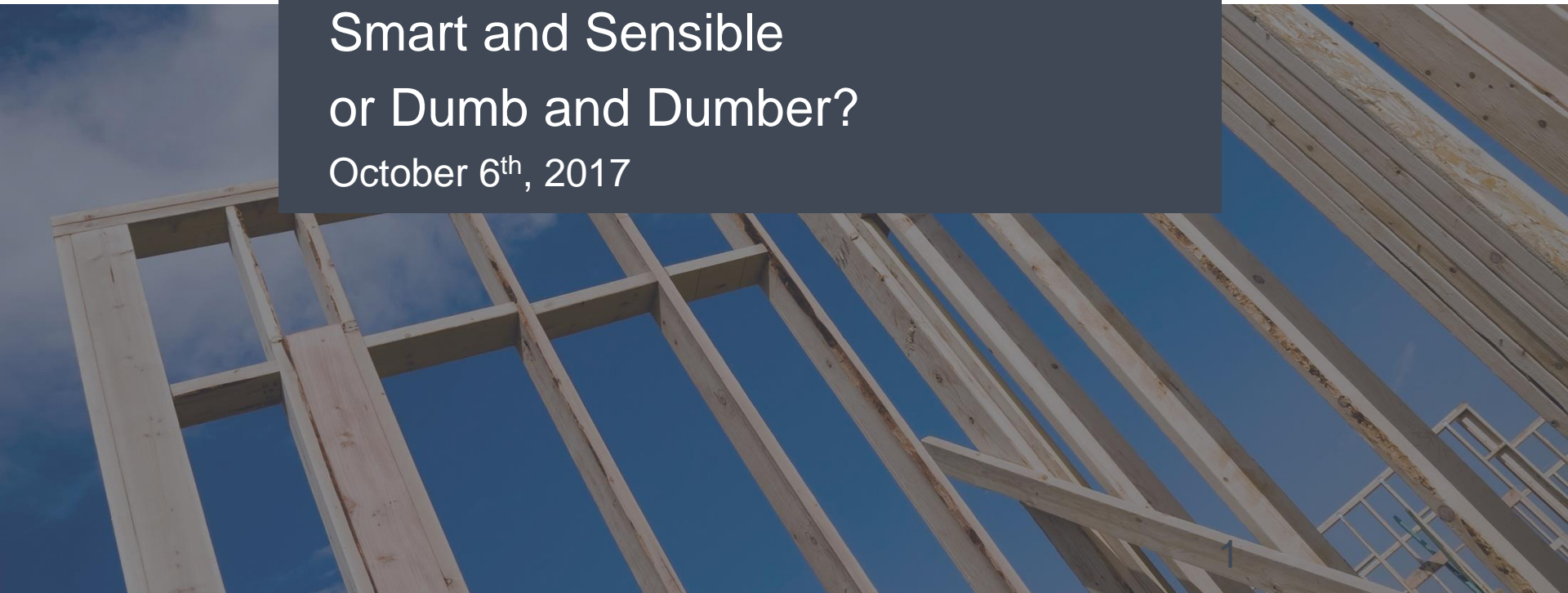


# BetterBuilt<sup>NW</sup>

## Connected Thermostats

Smart and Sensible  
or Dumb and Dumber?

October 6<sup>th</sup>, 2017



# Housekeeping

## Welcome

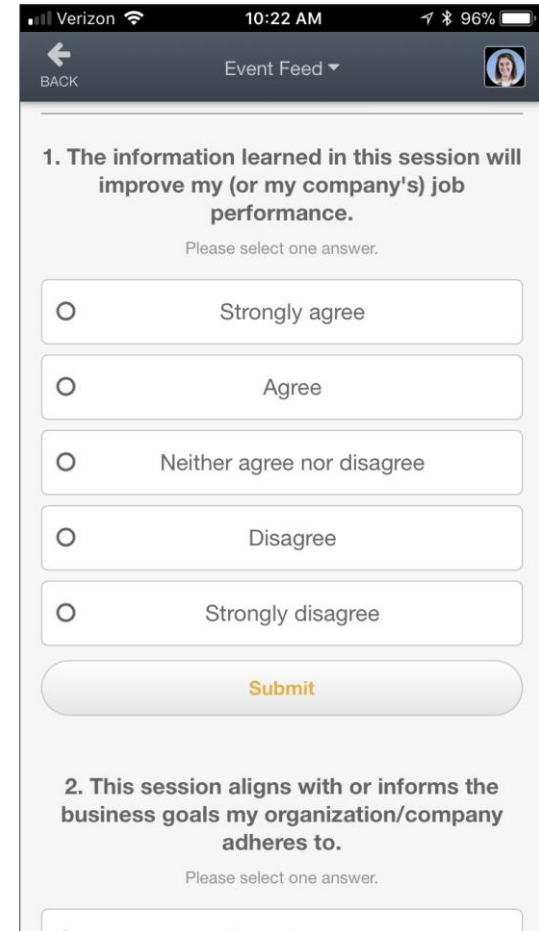
- Safety
- Bathrooms
- Cell phones



# Session Survey Instructions

At the end of each session, you will be given 5 minutes to complete the session survey.

1. Open the “HEF2017” app
2. Navigate to “Agenda” and select the session
3. Scroll down to “Session Feedback”
4. For each question, select answer and hit “Submit”
5. Show completed survey to BetterBuiltNW rep to earn points
6. Prizes awarded Friday to the top point earners
  - See “Challenge” section in the app for activities
7. Assistance available at the BetterBuiltNW table



The screenshot shows a mobile app interface for a survey. At the top, the status bar displays 'Verizon', signal strength, Wi-Fi, 10:22 AM, and 96% battery. The app header includes a 'BACK' button, 'Event Feed' with a dropdown arrow, and a user profile icon. The main content area displays a survey question: '1. The information learned in this session will improve my (or my company's) job performance.' Below the question, it says 'Please select one answer.' and provides five radio button options: 'Strongly agree', 'Agree', 'Neither agree nor disagree', 'Disagree', and 'Strongly disagree'. A 'Submit' button is located below the options. The second question is partially visible at the bottom: '2. This session aligns with or informs the business goals my organization/company adheres to.' with the instruction 'Please select one answer.'

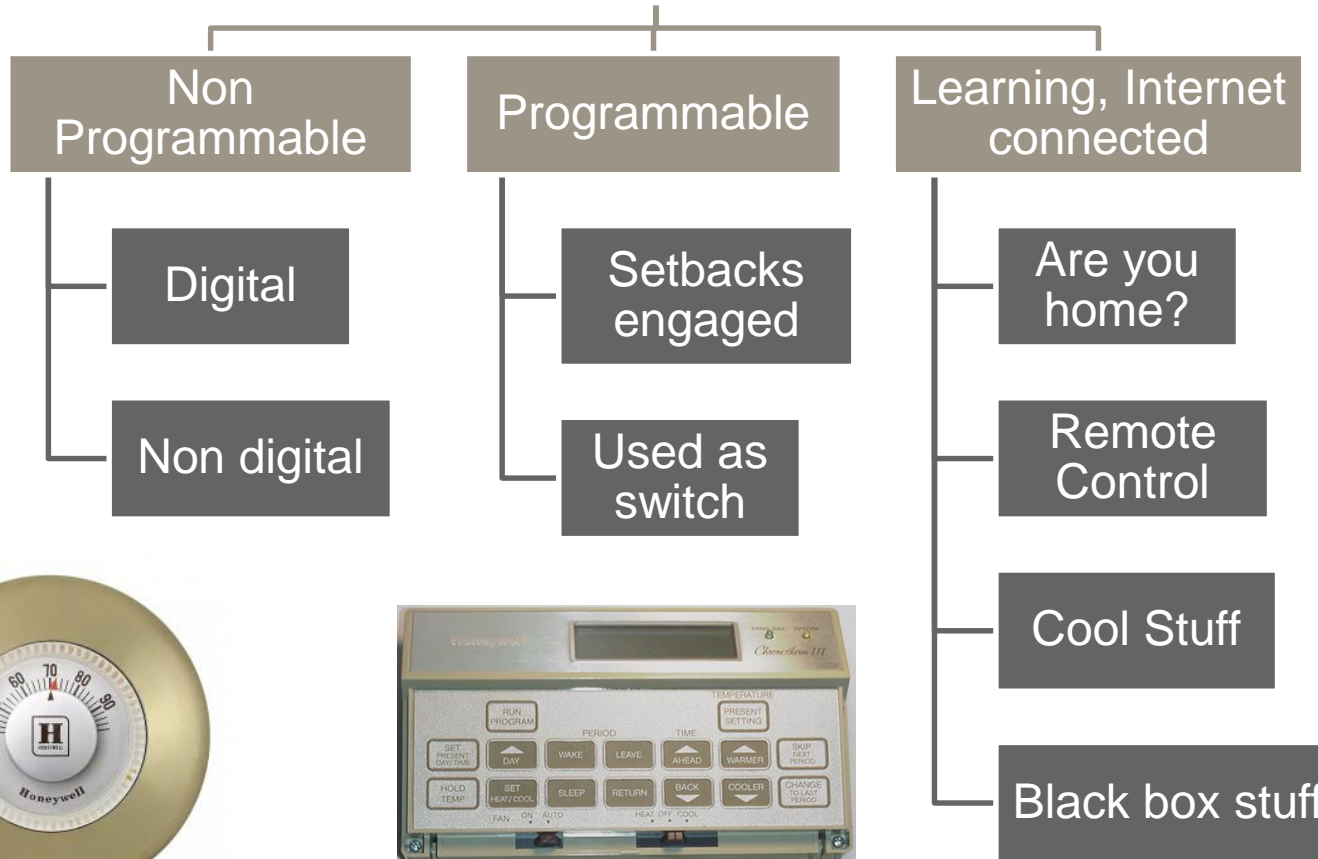
# About This Session

- Few answers
- Lots of questions
- ...and some advice



# Thermostat Groups

## All Thermostats



# What are Smart Thermostats?

Programmable thermostats	Occupants set schedules and setbacks to match their lifestyle; programmable thermostats do not have occupancy or proximity sensors
	Ability to maintain comfortable temperatures in a structure
	Displays temperatures and operating modes
Wi-Fi thermostats	Wi-Fi-enabled
	Online dashboard and/or mobile app connected to the user account
	Intuitive user interface, or UI, that may include touchscreen or buttons
Smart thermostats	Occupancy sensing that directly detects occupants by internal sensor and adjusts the thermostat accordingly
	Proximity sensing that indirectly detects occupants by external device, like a smart phone, and adjusts thermostat accordingly
	Algorithms that learn occupant behavior to improve schedules and learn characteristics of the structure to improve performance of the system
	Basic demand response capabilities that allow remote connection with utilities, who can adjust thermostat settings during peak demand periods (optional)

# ENERGY STAR Smart Thermostat

- Must have certain features
- Must have some evidence of actual change in set points
- Must somehow have the ENERGY STAR logo

## SMART THERMOSTATS

OVERVIEW

SPECIFICATION

PROMOTIONS



Make the smart choice for your new thermostat by choosing ENERGY STAR certified smart thermostats. Only thermostats that have earned the ENERGY STAR deliver what you expect from a smart thermostat: including demonstrated energy savings and environmental benefits as well as reliable performance and convenience, insight and control. ENERGY STAR is the smart choice made simple.



# The Details

## Smart Thermostats Key Product Criteria

ENERGY STAR certified smart thermostats are required to:

- Work as a basic thermostat in absence of connectivity to the service provider.
- Give residents some form of feedback about the energy consequences of their settings.
- Provide information about HVAC energy use, such as monthly run time.
- Provide the ability to set a schedule.
- Provide the ability to work with utility programs to prevent brownouts and blackouts, while preserving consumers' ability to override those grid request

Parameter	Performance Requirement
Static temperature accuracy	$\leq \pm 2.0$ °F
Network standby average power consumption	$\leq 3.0$ W average
Time to enter network standby after user interaction (on device, remote or occupancy detection)	$\leq 5.0$ minutes

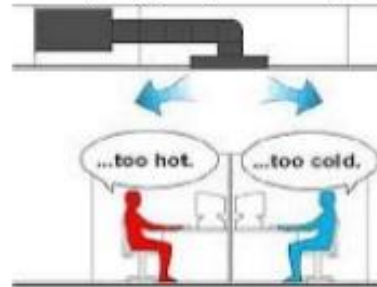


# Thermostats Can Be Smart and Not Save Energy

## Definition



Thermal comfort is the condition of mind that expresses satisfaction with the thermal environment and is assessed by subjective evaluation (ANSI/ASHRAE Standard 55). Thermal environment is those characteristics of the environment which affects a person's heat loss. In terms of bodily sensations, thermal comfort is a sensation of hot, warm, slightly warmer, neutral, slightly cooler, cool and cold.



Comfort  
(could increase  
energy use)

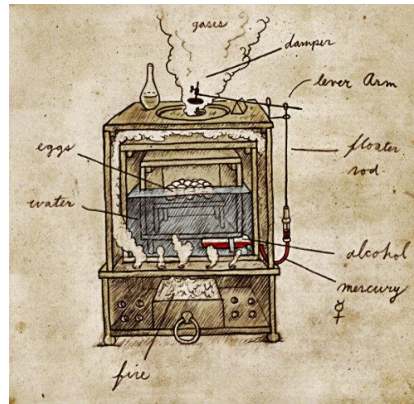
Convenience

Peace of mind

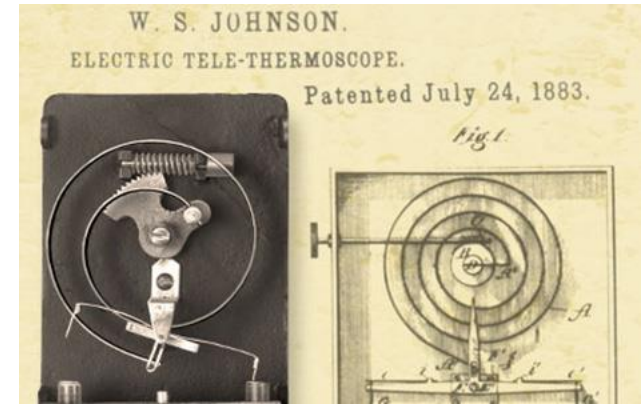
# A Short History of the Thermostat: Hardware to Software



Cornellis Drebbel  
1592



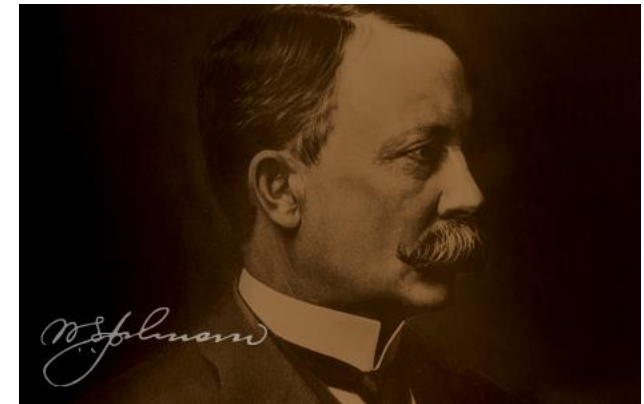
The "magic oven"



Albert M. Butz



1885 the "damper flapper"



Warren Johnson

# More Recent History



1st Programmable  
Thermostat  
1906



The Chronotherm II Adaptive  
intelligent Recovery



Ecobee  
2007

1953  
T-87



Vision Pro






# Smart Thermostats are Not A Commodity

- Term *commodity* is specifically used to describe a class of goods for which there is demand, but which is supplied without qualitative differentiation across a market.



# Smart Thermostats: Key Differences

- User interface
- Motion sensor
- Ability to control other devices
- Demand response capabilities
- Report capabilities
- Behavioral prodding
- Control algorithm
- Data sharing
- Geo-fencing
- App reliant
- Design appeal

A photograph of two construction workers on a building site. The worker on the left is wearing a white hard hat, a light blue shirt, and dark pants, pointing towards the wooden framing of a building. The worker on the right is wearing a blue shirt, blue jeans, and a tan tool belt, holding a hammer. The background shows the wooden skeleton of a building under construction against a clear blue sky. A dark grey text box with white text is overlaid on the right side of the image, and an orange square is on the left side.

# Pilots: Yes, Smart Thermostats Can Save Energy

# Completed Pilots

## Energy Trust of Oregon

- DI Nest t-stats for 200 homes with heat pumps and 200 control homes
- Installed by Pilot staff
  - Installation Method: Installed by CLEAResult staff
  - Issues Faced: Bricked product: Close calls on customer service

## Franklin PUD

- 176 homes, small control group
- Installed by HVAC contractors
  - Installation method: Installed by 3<sup>rd</sup> party HVAC contractor
  - Issues faced: Contractor training hurdles

## Energy Trust of Oregon

- Gas heated homes
- DIY/Self-install, with Geo Fencing



# Savings From The ETO Heat Pump Pilot

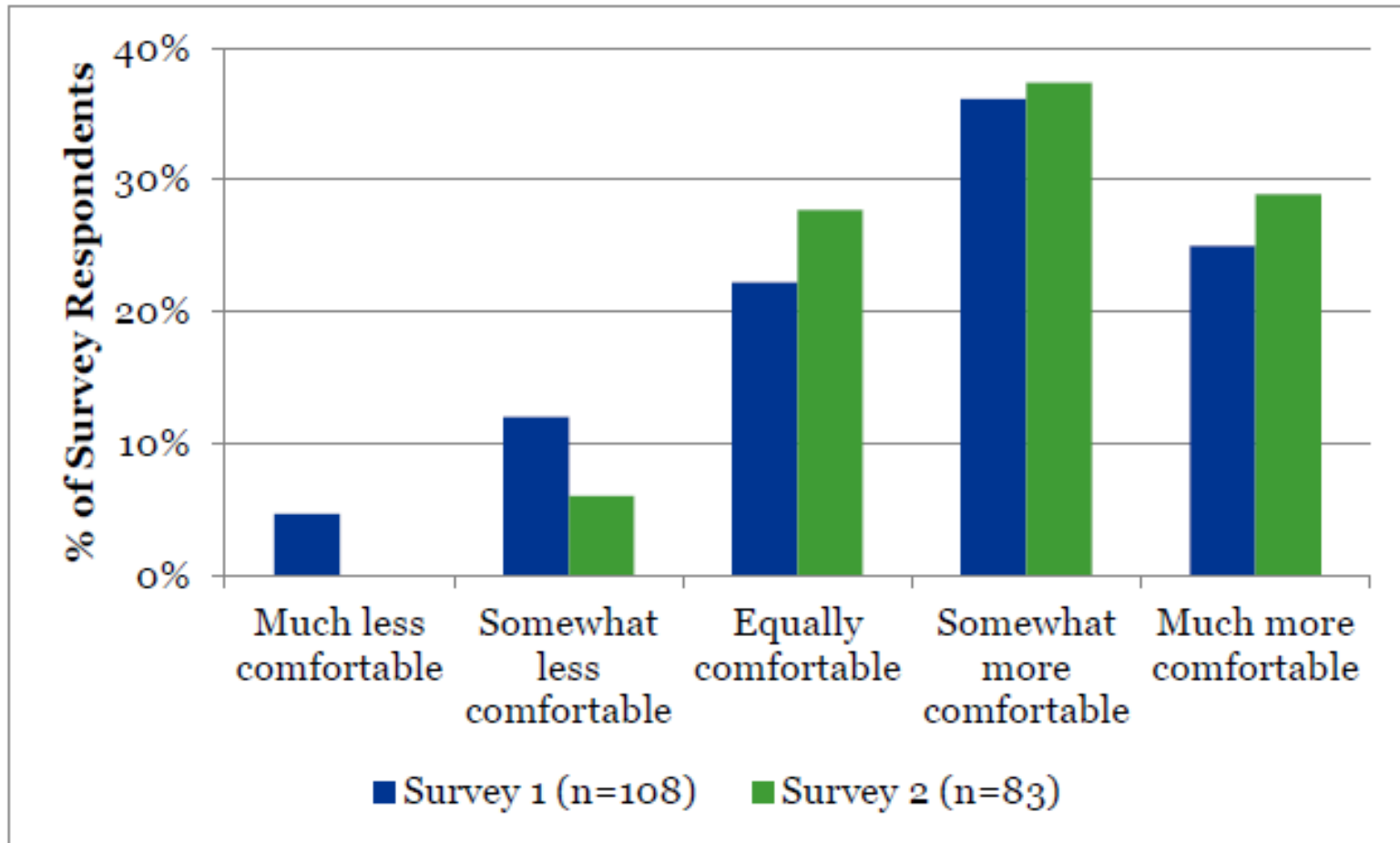
Table 15. Nest weather-normalized annual electric savings by home construction type.

Construction Type	Participant N / Comparison N	Annual Savings (90% CI)	Std. Err.	p-value	Annual Usage	% Savings (90% CI)	Realization Rate
Manufactured	21 / 54	1,172 (470, 1874)	388	0.013	13,521	8.7% (3.5, 13.9)	140%
Site-built	92 / 157	669 (105, 1232)	311	0.057	17,532	3.8% (0.6, 7.0)	80%

Construction Type	Annual Savings
Manufactured	8.7%
Site-built	3.8%

# Increased Comfort

Figure 24. Comfort of home temperature compared to pre-Nest thermostat period



Data and Graphics From Energy Trust of Oregon and Apex Analytics

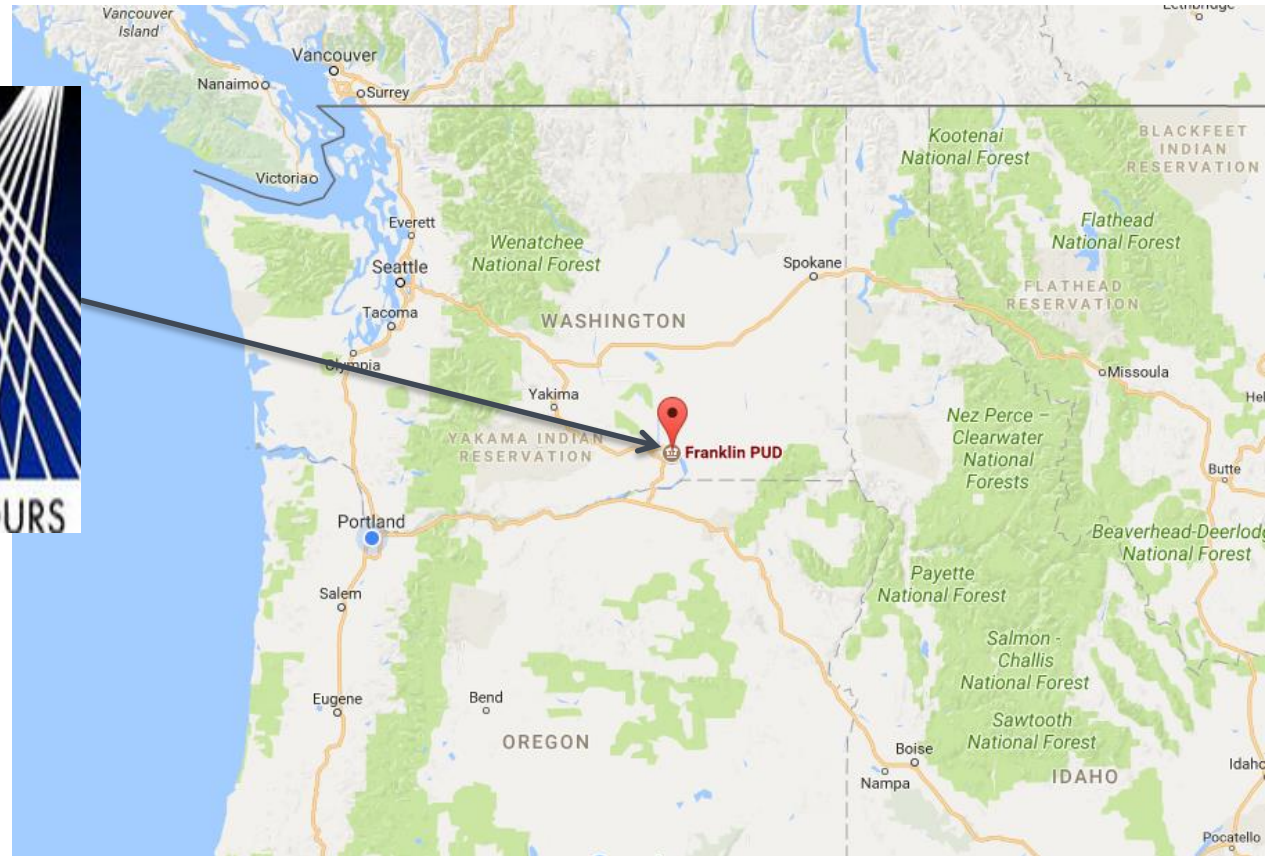
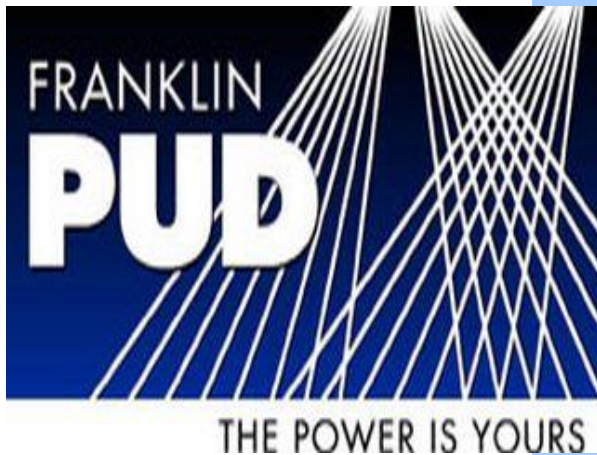
# What Were They Programmed To Do?

Table 22. Nest weather-normalized annual electric savings by prior thermostat type (Comparison N=211).

Prior Thermostat Type	Participant N	Annual Savings (90% CI)	Std. Err.	p-value	Annual Usage	% Savings (90% CI)	Realization Rate
Not programmable	28	423 (-384, 1230)	445	0.365	14,656	2.9% (-2.6, 8.4)	51%
Programmable	82	1,151 (621, 1681)	293	0.003	17,619	6.5% (3.5, 9.5)	138%

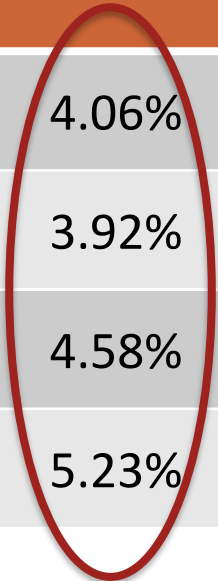
Prior Thermostat Type	% Savings (90% CI)
Non programmable	2.9% (-2.6, 8.4)
Programmable	6.5% (3.5, 9.5)

# Franklin PUD Project



# The Answer is.....

N	Total Annual Savings (kWh)	95% Lower C.I.	95% Upper C.I.	R-Squared Criteria	Pre Install Consumption	% Total Savings
167	885	381	1388	All	21804	4.06%
130	824	314	1333	$\geq .50$	21016	3.92%
115	959	419	1498	$\geq .60$	20930	4.58%
97	1103	599	1607	$\geq .70$	21110	5.23%

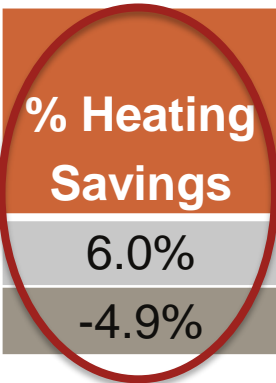


Data from Phillip Kelsven and Robert Weber, BPA

# Findings on the Energy Trust of Oregon DIY Gas Furnace Pilot

Thermostat	Annual Therm Savings	SE	90% Conf. Interval	p-value
Nest	34	11	13, 55	0.018*
Lyric	-29	14	-55, -3	0.071*

Thermostat	% Savings	% Heating Savings	Annual Therm Usage	Heating Therm Usage	% Heating Usage
Nest	4.5%	6.0%	761	566	74%
Lyric	-3.7%	-4.9%	784	596	76%



Data and Graphics From Energy Trust of Oregon and Apex Analytics





**Considerations For  
Selecting the Best Fit  
Smart Thermostat**

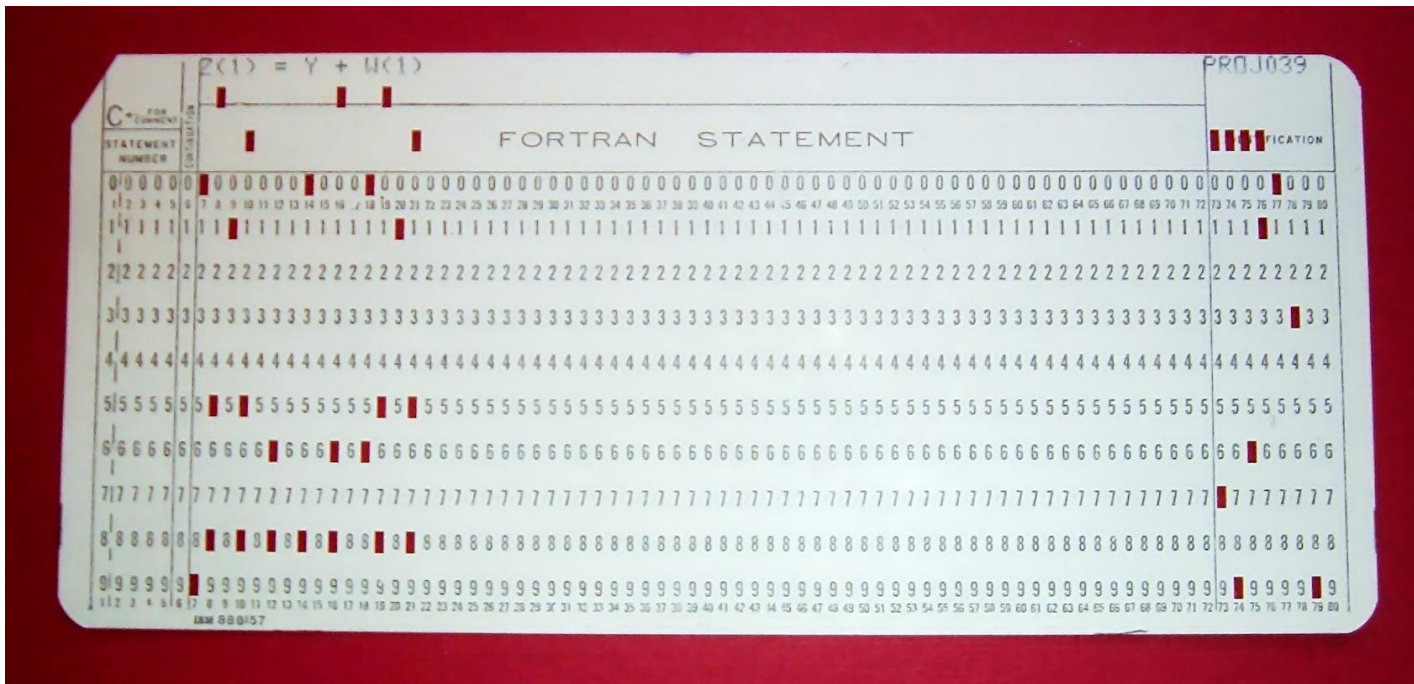


# Avoid Homeowner Confusion and Call Backs



# User Interface

- User Interface are like jokes; if you have to explain them, they aren't any good



# Proprietary Thermostats

- High End HVAC Systems Usually Need a Proprietary Thermostat To Have Full Functionality
- Modulating Gas Furnaces
- Variable Refrigerant Heat Pumps and Air Conditioners

# Smart Thermostats and Ductless Heat Pumps

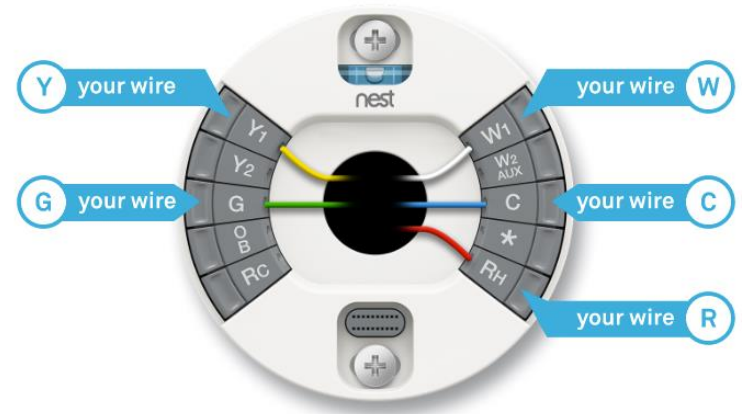
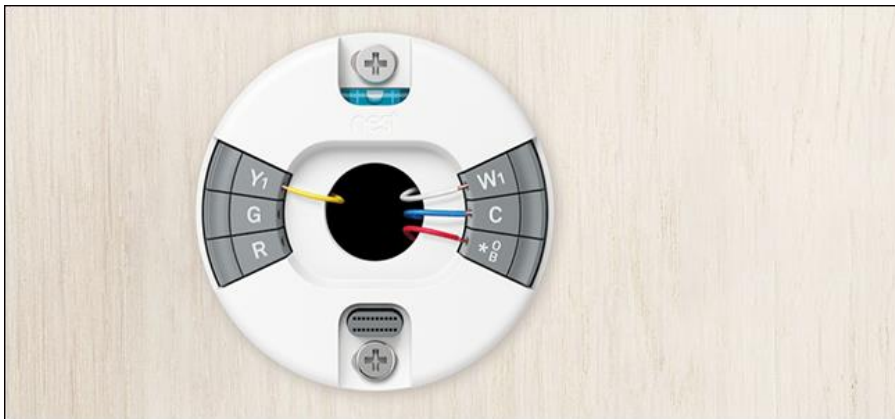
- DHPs already have smart algorithms. It may not be a good idea to layer another set on top.
- If available, use the manufacturer's Wi-Fi thermostat.



# Nest 3 vs. Nest E



- Same basic features
- The “E” only has 6 wire terminals limiting equipment types and HVAC accessories



# Whose Job is it?



Connected thermostats require someone to connect them to the homeowners Wi-Fi:

- The homeowner
- The Builder
- The HVAC Technician
- The Rater/Verifier

# Compatibility With Other Smart Stuff

Can the system grow?

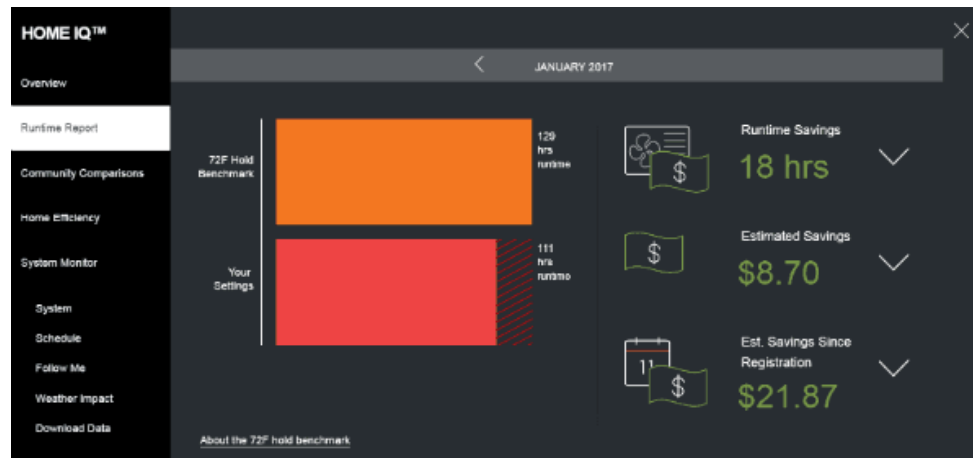
- Security
- Smoke and Carbon Monoxide detectors
- Alexa or other hubs
- Home Kit – works with Nest
- Smart Fans, smart doggie doors, etc.



# Energy Reports: Built in Data Logging

So much data, who has access?

- The builder?
- The verifier?
- The owner?
- The HVAC contractor?



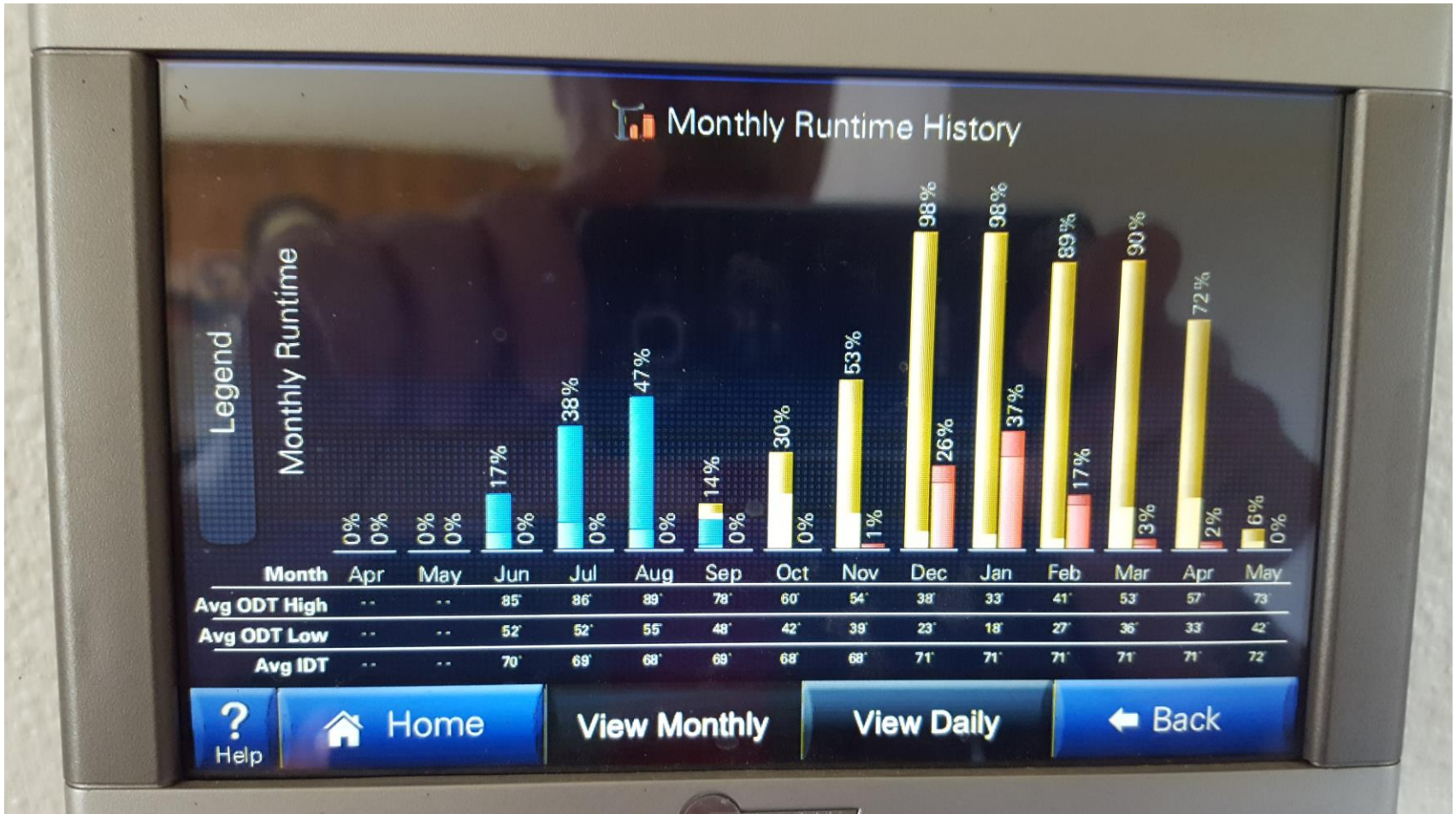
# Remote Monitoring and Service Alerts

**History**


Historical Data	Cycle Count				Run Time (all times in hours)			
	Today	Last 7 Days	Current Month	Last Month	Today	Last 7 Days	Current Month	Last Month
Y1 Cooling	0	0	0	0	0	0	0	0
Y2 Cooling	0	0	0	0	0	0	0	0
Y1 Heating	10	114	66	653	3.7	75.2	37.4	514.7
Y2 Heating	5	40	22	333	2.6	54.1	25.2	401.3
W1	0	40	12	162	0	2.4	0.7	11
W2	0	6	2	24	0	1	0.3	4.4
W3	0	0	0	0	0	0	0	0
Defrost Cycles	0	6	2	24	0	1	0.3	4.4
DTS Limit Trip	0	0	0	0				
Humidifier	0	0	0	0	0	0	0	0

? Help   Service Menu   ← Back

# Can be Viewed Remotely or On Site



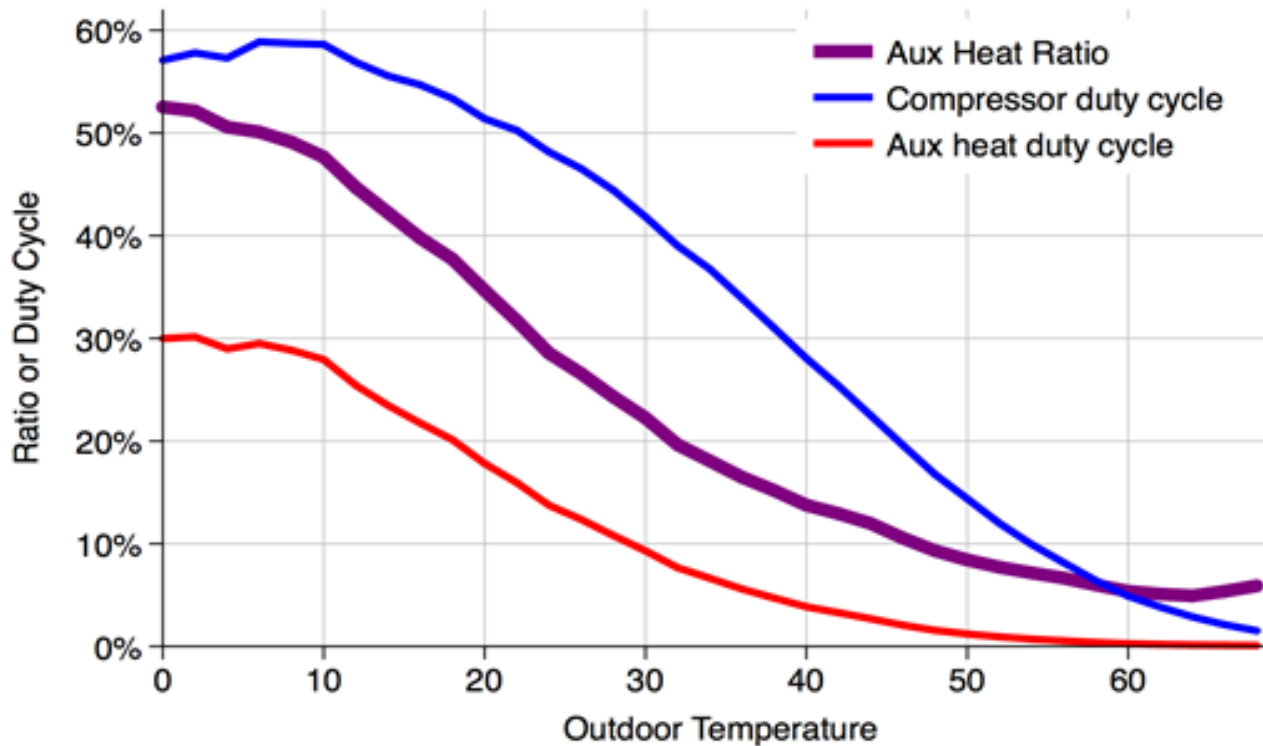


A photograph of a wooden building frame under construction, showing a complex network of beams and trusses. The structure is set against a clear blue sky. In the foreground, there are stacks of lumber and a wooden floor. A dark blue rectangular box with white text is overlaid on the right side of the image, and an orange L-shaped graphic is on the left side of the text box.

# Remote Quality Control and Data Logging

# What's Next: Smart T-stat as QC

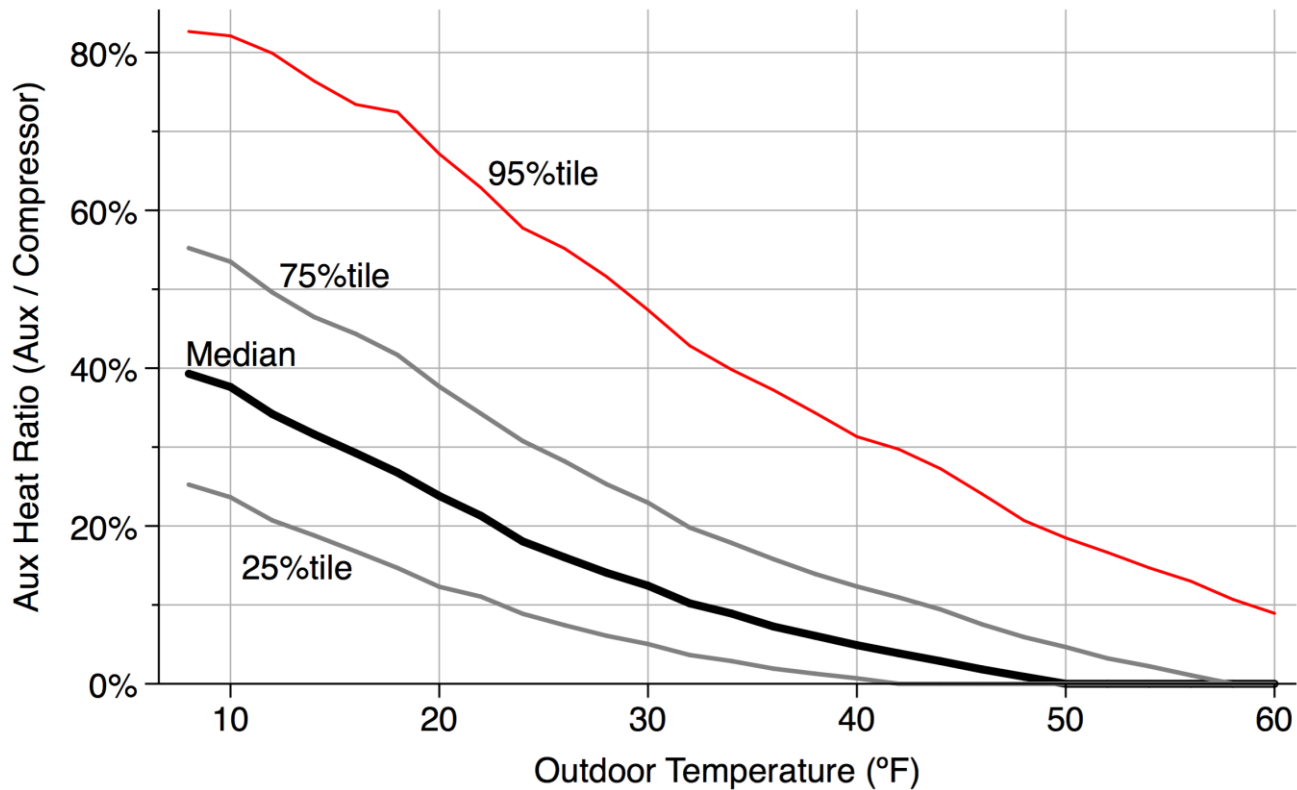
Heat Pump Duty Cycle vs. Tout  
US Jan-Mar 2015



# What's Next: Smart T-stat as QC

Heat Pump Aux Heat Ratio vs. Outdoor Temperature

US Jan-Mar 2015



# What was found

Site ID	City	Year Built	Sq. ft.	MH Type	Tonnage	Annual kWh in pre-period	Strip Heat Ratio
683853	Bend	1996	1400	Double-wide	2	10452	49%
683890	Bend	1997	1400	Double-wide	2	19685	14%
677995	Bend	1997	1620	Double-wide	2.5	23871	9%
139287	Oregon City	1991	1292	Double-wide	2	15114	7%
25106	Oregon City	1991	1080	Double-wide	2	18094	5%
690344	Terrebonne	1997	1296	Double-wide	2	13630	4%
689461	Bend	1997	1200	Double-wide	2	16089	3%
543542	Oregon City	1995	1800	Double-wide	3	13377	2%
497998	Oregon City	1995	1290	Double-wide	2	11861	2%
325913	Bend	1988	1980	Double-wide	3	17161	2%
690383	Oregon City	1996	1296	Double-wide	2	7230	1%
689451	Bend	1995	1810	Double-wide	3	Not found	1%
583813	Oregon City	1987	1296	Double-wide	2	17410	0%
562026	Oregon City	1990	1568	Double-wide	2.5	10711	0%
520339	Portland	2014	1500	Double-wide	2.5	13310	0%
467510	Bend	1997	1400	Single-wide	2	23871	0%
231255	Oregon City	1990	1400	Double-wide	2.5	12601	0%
467251	Bend	1997	1400	Double-wide	2.5	13761	0%
683842	Oregon City	2013	1917	Double-wide	3	14744	0%

 Annual kWh in pre-period is metered use reported to the utility.



# What We Found

Site ID	Aux Heat Ratio	Delta Capacity	% Below or Above	Thermostat Settings	ACH at 50Pa	Duct Leakage CFM	Reasons for high aux heat ratio
1173489	0	2114	9%	Strip heat locked out at 35F.	6.8	62	
1156226	0	-6009	-20%	Max Savings	19.4	550	
231255	0	-3272	-11%	Max Savings	7.2	138	
562026	0	-5961	-20%	Max Savings	5.1	707	
1171519	4	54	0%	Max Savings	10.0	274	
139287	7	-5427	-23%	Max comfort	10.3	238	Set to Max Comfort, 23% low on capacity
1138572	9	-11966	-40%	Max comfort -	5.4	250	Set to Max Comfort, Very low capacity
1156212	14	-1709	-7%	Max Savings	10.4	225	Homeowner used deep set backs
1156132	49	3721	16%	Locked out compressor at 35F	9.0	176	Locked out compressor

# Preliminary Conclusions

- All thermostats can cause control problems
  - But connected thermostats can find them!
- Maybe by comparing run times and using connected thermostats “problem” homes or systems can be found

# Our Best Advice

- Choose a compatible thermostat for your HVAC system
- Decide who will commission the thermostat
- User friendly is better
- Ask the owner for data access
- Educate the homeowner

# Evaluations Matter: Both Teams Have the Same Features





# Thank You

Bruce Manclark

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